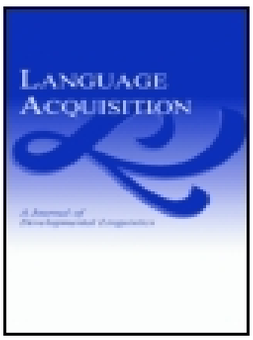

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The influence of cognitive abilities on article choice and scrambling performance in Dutch-speaking children with autism

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ABSTRACT

This study addresses the question as to what cognitive abilities influence performance on article choice and direct object scrambling in high-functioning Dutch-speaking children with Autism Spectrum Disorder (ASD). Schaeffer (2016/2018) shows that a group of 27 high-functioning Dutch-speaking children with ASD, aged 5–14, overgenerates the indefinite article, and fails to scramble significantly more often than TD age-mates. As article choice, direct object scrambling, and false belief are all hypothesized to rely on perspective taking, we first predict a correlation between scores on article choice, direct object scrambling, and false belief. Furthermore, hypothesizing that article choice and direct object scrambling require holding the previous discourse in mind, it is predicted that memory abilities predict article choice and direct object scrambling performance. Surprisingly, the results reveal no correlation between article choice, direct object scrambling, and false belief. Moreover, no influence of working memory was found, nor of inhibition or morphosyntax, which were also tested. Phonological memory turns out to be the only cognitive ability that predicts scores on direct object scrambling (but not on article choice!). It is suggested that another cognitive skill may contribute to article choice and/or direct object scrambling, namely, central coherence.

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1. Introduction

Language can be viewed as a cognitive function that may or may not interact with other cognitive functions, as illustrated in Figure 1 (not exhaustive). One of the common themes in my research is the question: To what extent are (the development of) linguistic components such as pragmatics and (morpho)syntax associated with (the development of) extralinguistic cognitive functions, such as intelligence, theory of mind, and executive functions (including memory)? My goal is to be able to draw lines and arrows between components such as the ones in Figure 1 to show that there is an interaction or relationship, or no lines, to indicate the opposite.

This study takes autism as a testing ground and investigates if and how (morpho)syntax, pragmatics, (working) memory, inhibition, theory of mind and intelligence are related in the developing minds of high-functioning Dutch-speaking children with Autism Spectrum Disorder (ASD).[1] ASD is a developmental disorder, and one of its characteristics is impairments in social interactions in both verbal and nonverbal communication (DSM 5; American Psychiatric

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[1]The data used for this study overlap with the data analyzed for a study by Schaeffer that appeared in *Language Acquisition* in 2016 (online)/2018 (on paper) on linguistic and other cognitive abilities of children with specific language impairment (SLI) and how they are similar/different from those of high-functioning children with ASD. The current study concentrates on ASD only and therefore makes use of the data from (the same) high-functioning children with ASD only. It also includes data from additional tests administered to the children with ASD that were not discussed in the 2016/2018 publication in *Language*

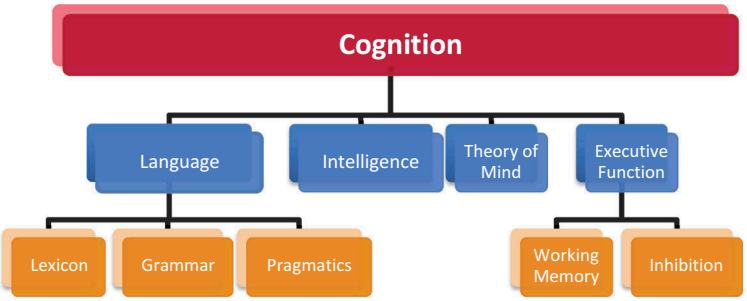


Figure 1. Language and other cognitive functions.

Association 2013). ASD has an average prevalence estimated to be 1/160 (World Health Organization 2019), and the literature reports a primary language impairment in pragmatics. For a long time, grammar has been assumed to be intact, but recent research indicates that problems within grammar can exist as well. Regarding extralinguistic cognition, the results are mixed. Many (but not all) studies report impairments in theory of mind (ToM), and the results on executive functions (EF), including working memory (WM), often contradict each other. For a more elaborate description of the relevant characteristics of ASD and references to the literature, see section 2.

It is thus important that we conduct more fine-grained research on the development of different language components in relation to other cognitive functions in children with ASD and that we try to explain what the underlying causes of potential language difficulties are. To a certain extent, Schaeffer (2016/2018) did this by showing that the high-functioning Dutch-speaking children with ASD she tested are not impaired in morphosyntax but perform significantly more poorly on certain linguistic-pragmatic phenomena. However, the relationship between the ASD group's weak linguistic pragmatics and extralinguistic verbal and nonverbal cognitive functions was not examined. Furthermore, Schaeffer, Creemers & van Witteloostuijn (2018) investigated the associations between one linguistic-pragmatic phenomenon (article choice, see section 2.2), different types of memory, and theory of mind in children with Specific Language Impairment (SLI) and high-functioning children with ASD and found a correlation between phonological memory and article choice for the combined groups but not for any of the groups separately. The current study concentrates on the potential associations between linguistic pragmatics, morphosyntax, and extralinguistic cognition by analyzing the results of two linguistic-pragmatic measures, two (morpho)syntactic measures, and several extralinguistic cognitive measures in the same group of Dutch-speaking high-functioning children aged 6–14 with ASD.

The article is organized as follows. Section 2 starts with a brief overview of relevant characteristics of high-functioning children with ASD and previous studies on language and other cognitive development in autism. This is followed by a description and discussion of the linguistic-pragmatic and (morpho)syntactic phenomena in question in Dutch adult language and existing theories that account for them. An overview of the acquisition of these phenomena by typically developing children is also provided. The section is concluded by hypotheses and predictions regarding connections between the linguistic-pragmatic skills of high-functioning Dutch-speaking children with ASD on the one hand and their extralinguistic cognitive and morphosyntactic abilities on the other hand. Section 3 presents the methods used to test linguistic pragmatics, (morpho)syntax, and extralinguistic cognition. The results are presented in section 4 and

Acquisition. While the goal of the 2016/2018 study was to show how the profiles of children with SLI and high-functioning children with ASD differ from each other, the present study investigates the question as to whether and how (potential weaknesses in) pragmatics, (morpho)syntax, and extralinguistic cognitive skills interact in high-functioning children with ASD. Schaeffer, Creemers & van Witteloostuijn (2018) used part of the same data set of 2016/2018 and investigated associations between article choice, memory, and theory of mind in high-functioning children with ASD and children with SLI. Correlation analyses were performed on the combined group of SLI and ASD. The current study focuses on the relationship between several more linguistic and extralinguistic cognitive phenomena, and in the ASD data set only.

discussed in section 5. The data show very little evidence for an association between impaired pragmatics and weaknesses in (morpho)syntax or extralinguistic cognitive functions such as intelligence, ToM, or EF. As such, we conclude that the pragmatic weaknesses we find in the high-functioning ASD group we tested may need a different explanation, which we speculate on.

2. Background

2.1. *High-functioning children with ASD*

High-functioning children with ASD are typically characterized as having a normal or high IQ and fluent speech, but impaired communication and deviant pragmatics (see Baron-Cohen 1988; Eigsti et al. 2011; Frith 1989; Tager-Flusberg 1989 for reviews). Subgroups of children with ASD have been reported to have additional grammatical impairments (Durrlemann, Marinis & Franck 2016; Janke & Perovic 2015; Kjelgaard & Tager-Flusberg 2001; Perovic, Modyanova & Wexler 2013a, 2013b; Prévost et al. 2017; Terzi et al. 2014; a.o.), leading to the labels ALN (Autism Language Normal) and ALI (Autism Language Impaired).

Regarding their extralinguistic cognitive abilities, (high-functioning) children with ASD often have an impaired ToM (Baron-Cohen et al. 1988; Colle, Baron-Cohen and Hill 2007; Durrleman et al. 2016; Sperber & Wilson 2002, a.o.). As for verbal working memory, the results are inconsistent. Some studies show working memory deficits in children with ASD (Joseph et al. 2005; Schuh & Eigsti 2012), while other studies report normal performance (Griffith et al. 1999; Koshino et al. 2005; Ozonoff & Strayer 2001; Russell, Jarrold & Henry 1996) or mixed performance (e.g., Bennetto, Pennington & Rogers 1996). Nonverbal (visuo-spatial) working memory in individuals with ASD, including high-functioning ones, can be impaired but not always (Bennetto, Pennington & Rogers 1996; Luna et al. 2002). Phonological (short-term) memory, often tested by repetition of nonsense words, has been shown to be impaired in children with ALI but not in children with ALN (Kjelgaard & Tager-Flusberg 2001; Tager-Flusberg 2006, 2015). Finally, children with ASD often demonstrate impaired performance on inhibitory control tasks but not always and not on all tasks (Adams & Jarrold 2012; Christ et al. 2007).

In summary, studies on the extralinguistic abilities of children with ASD report mixed results and hardly ever relate these results to the linguistic capacities of children with ASD. The current study attempts to fill this gap by investigating both linguistic and extralinguistic cognitive abilities in high-functioning children with ASD. In the next sections I provide some theoretical background of the linguistic phenomena under investigation and discuss a few relevant acquisition studies of these phenomena.

2.2. *Article choice*

The first pragmatic phenomenon investigated in this study is article choice. The choice between a definite and an indefinite article depends on speaker and hearer assumptions about the existence of the referent, which is why it is often categorized as a pragmatic phenomenon. Consider the sentences in (1) and (2):

(1) a. *Dit is een verhaal over* ***een*** *(bepaalde) vrouw.*
'This is a story about **a** (certain) woman."

b. ***De*** *vrouw woonde in een hutje.*
'**The** woman lived in a hut.'

(2) *Ik heb zin om* ***een*** *taart te bakken (wat voor taart dan ook).*
'I feel like baking **a** cake (whatever cake it may be).'

The referent for *vrouw* 'woman' in (1a) is introduced with an indefinite article. In (1b), *vrouw* becomes definite (*de vrouw* 'the woman') because its referent has been placed in the so-called Common Ground between speaker and hearer (Heim 1982; Stalnaker 1974, 1978, a.o.). Notice that the indefinite article in (1)

is different from the indefinite article in (2). In (1), the speaker assumes the referent of *vrouw* 'woman' to exist, but the hearer does not. This noun phrase is referred to as a referential indefinite ("a certain woman"). In (2), neither the speaker nor the hearer assumes the existence of the referent of *taart* 'cake.' This noun phrase is referred to as a nonreferential indefinite ("whatever cake it may be"). This is summarized in Table 1, presenting one type of definite (referential) and two types of indefinites (referential and nonreferential) in Dutch as well as in English (adapted from Schaeffer & Matthewson 2005).

The choice between a definite and an indefinite article is thus driven by referentiality, which in turn is determined by speaker/hearer assumptions. Speaker and hearer assumptions are based on general world knowledge but also on the preceding discourse, as the sentence pair in (1) shows: The definite article *the* can be used because in the preceding sentence the referent was introduced by an indefinite. The fact that both speaker/hearer assumptions and discourse are involved in article choice leads us to categorize article choice as a pragmatic phenomenon.

Cross-linguistic research on the acquisition of article choice indicates that young typically developing (TD) children often produce definite articles in indefinite contexts (Karmiloff-Smith 1979; Maratsos 1976; Schaeffer & Matthewson 2005; van Hout, Harrigan & de Villiers 2010; Zehler & Brewer 1982). Explanations of this child error are often pragmatic in nature. For example, Schaeffer & Matthewson (2005) propose the lack of the pragmatic "Concept-of-Non-Shared-Assumptions" (CNSA), stating that speaker and hearer assumptions are always independent. If children lack this, speaker and hearer assumptions are not always independent, implying that there are situations in which the speaker automatically attributes her/his own assumptions to the hearer. Assuming article choice to work as in Table 1, it becomes clear that this can result in the use of the definite article *the* in contexts in which adults, who do have the CNSA, would use the indefinite article *a*. As Schaeffer & Matthewson (2005) note, the CNSA reminds of ToM, the cognitive ability to attribute mental states to one self and others (Premack & Woodruff 1978). As such, the CNSA may well be a precursor or component of ToM.

As for comprehending definite and indefinite articles, van Hout, Harrigan & de Villiers (2010) report non-adult-like interpretation of the indefinite article *a* in English-acquiring TD children aged 3;07–5;03 (mean: 4;06). These children often interpreted the indefinite article *a* to refer to a determined referent (in Schaeffer & Matthewson's terms: A referent assumed to exist by both speaker and hearer). To explain this non-adult-like interpretation of indefinites van Hout, Harrigan & de Villiers (2010) propose that young children fail to draw scalar implicatures (see also Pouscoulous et al. 2007; a.o.). Hawkins (1991) and Horn (2006) argue that interpretation of an indefinite NP requires the calculation of a scalar implicature. They propose a definiteness scale <*a, the*>, in which *the* is the logically stronger and most informative member. A scalar implicature arises when the indefinite article is used: The use of the weak indefinite article implies that the stronger definite reading does not hold. Consequently, the indefinite article may be interpreted in two ways: It can receive an inference-driven, *pragmatic* reading excluding the definite reading, or it can get a literal, *logical/semantic* meaning (i.e., the existence of a referent). This logical/semantic meaning is also compatible with *the*: Whether a definite or an indefinite article is used, the truth-value of a sentence remains the same. Returning to van Hout, Harrigan & de Villiers's (2010) results, children arbitrarily choose between a determined referent meaning and a nondetermined referent meaning if they fail to draw a scalar implicature while interpreting indefinite NPs.

Also, in terms of production, indefinite articles are sometimes used infelicitously by TD children. The results of an elicitation task (without visual support) by Schafer & De Villiers (2000) show that English-speaking TD children (age 3;06–5;05) sometimes produce an indefinite article in definite contexts. The

Table 1. Definite and indefinite articles in adult English and Dutch.

Context	Assumed by	Label	Common ground	Article
A	Speaker and hearer	Definite-referential	Part of common ground	*de/the*
B	Speaker only	Indefinite-referential	Not part of common ground	*een/a*
C	Neither speaker nor hearer	Indefinite-nonreferential	Not part of common ground	*een/a*

authors argue that at this age, the children still have an immature ToM, causing inconsistent calculation of scalar inferences. Furthermore, Keydeniers, Eliazer & Schaeffer (2017) report that the Dutch-speaking TD 2-year-olds they tested also produce definite articles in contexts requiring a definite article and vice versa. Keydeniers et al. account for the overgeneration of definite articles by the lack of the CNSA, while van Hout et al.'s and Schafer & de Villiers's proposals that young children fail to consistently draw scalar implicatures are invoked to explain the overgeneration of indefinite articles.

As for high-functioning children with ASD, Schaeffer (2016/2018), and Schaeffer, Creemers & van Witteloostuijn report that the same Dutch-speaking children with ASD as examined in the current study score TD-like in indefinite contexts but overgenerate the indefinite article in definite contexts 15% of the time, which is significantly more often than the TD children (4%). The fact that the children with ASD scored according to the TD norm in indefinite contexts but deviated from TD children in definite contexts suggests that they did not use articles randomly without any system. A similar result was found for the children with SLI who were tested in these studies (TD-like in indefinite contexts, 13% overgeneration of indefinite article in definite contexts). Schaeffer, Creemers & van Witteloostuijn propose that weak phonological memory, especially in the children with SLI, decreases the chance to draw scalar implicatures appropriately, resulting in the occasional overuse of indefinites.

2.3. *Direct object scrambling*

Another phenomenon driven by referentiality and therefore by knowledge of speaker/hearer assumptions (pragmatics) is direct object scrambling. Direct object scrambling is the placement of a referential direct object in a position preceding the adverb or negation (Grewendorf & Sternefeld 1990; Karimi 2003; Ross 1986; van Riemsdijk & Corver 1994; a.o.). As illustrated in (3), a definite referential noun such as *het boek* 'the book' must be in pre-adverb or pre-negation position. If the direct object *het boek* 'the book' is in post-adverb or post-negation position, as in (4), it sounds odd.

(3) *Marijke heeft* ***het boek*** *goed/niet* ___ *gelezen*
Marijke has the book well/not ___ read
'Marijke read the book well'/'Marijke did not read the book'

(4) ??*Marijke heeft goed/niet* ***het boek*** *gelezen* (sentential negation)
Marijke has well/not the book read
'Marijke read the book well'/'Marijke did not read the book'

Indefinite nouns illustrate the scrambling phenomenon even more clearly: If an indefinite has a referential reading, as in (5), it needs to be scrambled, i.e., it needs to be in pre-adverb or pre-negation position. In contrast, if an indefinite is nonreferential, as in (6), it must remain unscrambled, i.e., in post-adverb or post-negation position.

(5) *Marijke heeft* ***een boek*** *goed/niet* ___ *gelezen* *Referential*
Marijke has a book well/not ___ read (a certain book)
'Marijke read a (certain) book well'/'Marijke did not read a (certain) book'

(6) *Marijke heeft goed/niet* ***een boek*** *gelezen* *Nonreferential*
Marijke has well/not a book read (any book)
'Marijke read a (some) book well'/'Marijke did not read a (any) book'

In a nutshell, the nonscrambled position, after the adverb or negation, is for nonreferential objects. The scrambled position, before the adverb or negation, is for referential objects.

TD Dutch-acquiring children often fail to scramble referential direct objects over negation when they are 2 and 3 years old. This is shown by a study by Schaeffer (1997, 2000), who conducted an Elicited Production Task with 49 monolingual TD Dutch-acquiring children between the ages of 2

and 7. Schaeffer argues that because young children do not distinguish between different types of referentiality, they do not have full knowledge yet of referentiality, resulting in occasional non-scrambling. As knowledge of referentiality is linked to speaker/hearer assumptions and what they are based on (e.g., information provided in the preceding discourse) Schaeffer (1997, 2000) concludes that it is immature pragmatics that causes failure to scramble.

Schaeffer (2016/2018) and Schaeffer (2017) investigated direct object scrambling in the same children with ASD examined in the current study and found that they performed according to the TD norm (i.e., no scrambling) in nonreferential contexts. However, they failed to scramble the direct object in referential environments (obligatory scrambling) 27% of the time. This was significantly more often than the TD children failed to scramble in these environments, namely, 8%. Similarly, the children with SLI also tested in these studies also performed significantly more poorly than the TD children: Although their scores were no different from the TD scores in the nonscrambling environments, they failed to scramble at a rate of 40% in obligatory contexts for scrambling. As did the article choice results (see section 2.2), these results suggest that direct object scrambling is not just random in these pathological populations. To explain the errors, Schaeffer (2017) relates the SLI group's poor performance on direct object scrambling to their weak syntactic abilities (recall that besides pragmatic knowledge of speaker/hearer assumptions and referentiality, direct object scrambling also requires word-order knowledge). In contrast, the scrambling errors of the children with HFA are argued to be caused by their difficulty to integrate pragmatic, semantic, and syntactic knowledge required for direct object scrambling.

2.4. *Subject-verb agreement*

Let us turn now to a morphosyntactic phenomenon. As illustrated in the table in (7), the verbal agreement suffix on the Dutch verb expresses person (in the singular) and number.

(7) Subject-verb agreement in Dutch present tense for the verb *werken* ("to work")

Person	Singular	Plural
1	*(ik) werk*	*(wij) werk-en*
2	*(jij) werk-t*	*(jullie) werk-en*
3	*(hij/zij/het) werk-t*	*(zij) werk-en*

As person and number are typical morphosyntactic features, subject-verb agreement is considered a morphosyntactic mechanism. Acquisition studies of subject-verb agreement in TD Dutch children report that verbal agreement is correctly expressed between age 2 and 3, i.e., from the moment children start to produce two-word utterances (Blom 2003). As Schaeffer (2016/2018) shows, the children with ASD also investigated in the current study performed no differently from the TD group on subject-verb agreement.

2.5. *Sentence repetition*

Another task that has been shown to measure morphosyntactic abilities is Sentence Repetition. As Marinis & Armon-Lotem (2015) point out, Sentence Repetition tasks have been used to evaluate the acquisition of specific (morpho)syntactic structures in children (L1) and adults (L2) (Bley-Vroman & Chaudron 1994; Jessop, Suzuki & Tomita 2007; Lust, Flynn & Foley 1996). Sentence Repetition tasks are also often employed in clinical settings and have been reported to be sensitive and specific in

identifying children with language impairment—in particular, (morpho)syntactic impairment (Conti-Ramsden, Botting & Faragher 2001, a.o.). See, for example, the Sentence Recall subtest from the Clinical Evaluation of Language Fundamentals (CELF) 3 (Semel, Wiig & Secord 1995).

Although a Sentence Repetition task of course also draws on phonological and semantic knowledge, as well as memory capacity, research has shown that participants must use their morphosyntactic system when repeating sentences. If sentences are long enough to disallow passive copying, participants draw on their own grammatical and memory systems to analyze and reconstruct the meaning of the sentence (Slobin & Welsh 1973; Ellis 2005; Erlam 2006). Interestingly, in a study on the interaction between different levels of linguistic representation and memory, Polišenská (2011) and Polišenská, Chiat & Roy (2015) demonstrate that morphosyntactic ability is one of the most important predictors of success on a Sentence Repetition task with long-enough sentences.

Regarding sentence repetition abilities in Dutch-speaking children with ASD, the Core Language Scores (including Sentence Recall) of the CELF-4-NL of the same high-functioning children with ASD as investigated in the current study show no differences with the TD group (Schaeffer 2016/2018).

2.6. *Research questions, hypotheses, and predictions*

In accordance with the literature reviewed in section 2.1 and as shown by Schaeffer (2016/2018), the linguistic-pragmatics of high-functioning Dutch-speaking children with ASD is impaired, specifically article choice (see also Schaeffer, Creemers & van Witteloostuijn 2018) and direct object scrambling (see also Schaeffer 2017). The question is why this is so. Is this pragmatic weakness caused by impairments in extralinguistic cognitive functions? Is it a consequence of morphosyntactic deficits?

Let us first consider the potential association with extralinguistic cognition. We know that children with ASD often have underdeveloped false belief. Both article choice and direct object scrambling rely on the determination of reference, which in turn makes use of speaker-hearer perspective taking. Perspective taking is also part of false belief. It is thus hypothesized that article choice, direct object scrambling, and false belief abilities are each influenced by perspective taking abilities. As such, article choice, direct object scrambling, and false belief abilities are predicted to correlate. The relation between executive functions and pragmatic phenomena is less clear, although it is feasible that phonological and working memory are involved in the pragmatics of article choice and direct object scrambling, since both phenomena require consideration of the preceding discourse and thus holding the preceding discourse in memory. It is therefore hypothesized that article choice and direct object scrambling are influenced by phonological memory and working memory. This renders the prediction that performance on phonological and working memory positively predicts performance on article choice scores and direct object scrambling. As it is not immediately obvious how inhibition would interact with article choice and/or direct object scrambling, this question is left open. The same applies to intelligence or, more specifically, nonverbal reasoning.

As for potential associations between pragmatics and (morpho)syntax, the phenomenon of direct object scrambling clearly requires syntactic knowledge: Besides referentiality, knowledge of object placement is involved too. This renders the prediction that performance on (morpho)syntactic measures positively predicts direct object scrambling performance. As for article choice, it is not clear that this requires much (morpho)syntactic knowledge. It is therefore predicted that performance on (morpho)syntax do not positively predict article choice performance.

Finally, age is a predictor for language development in the typically developing population: The older TD children, the better their linguistic abilities. It is an open question whether this is the case for high-functioning children with ASD as well.

The hypotheses, predictions, and open research questions regarding high-functioning children with ASD are listed here (8):

(8) Hypothesis 1:
Article choice, direct object scrambling, and false belief abilities are each influenced by perspective taking abilities.

Prediction 1:
Article choice, direct object scrambling, and false belief performance are correlated.

Hypothesis 2:
Phonological memory and working memory influence article choice and direct object scrambling.

Prediction 2a:
Phonological memory and working memory performance positively predict article choice performance.

Prediction 2b:
Phonological memory and working memory performance positively predict direct object scrambling performance.

Hypothesis 3:
(Morpho)syntax influences direct object scrambling but not article choice.

Prediction 3a:
(Morpho)syntax performance positively predicts direct object scrambling performance.

Prediction 3b:
(Morpho)syntax performance does not positively predict article choice performance.

Open Research Question 1:
Are article choice and/or direct object scrambling influenced by inhibition?

Open Research Question 2:
Are article choice and/or direct object scrambling influenced by nonverbal reasoning?

Open Research Question 3:
Is age a predicting factor for language performance in high-functioning children with ASD?

3. Methods

3.1. *Participants*

A total of 54 Dutch-speaking children participated in this study, divided over two groups: 27 high-functioning children with ASD (age 5–14, M = 10;01, SD = 2;03), and a control group of 27 TD children (age 6–14, M = 10;00, SD = 2;01). The two groups were individually matched on age and sex. The children with ASD were found through personal contacts, Dutch organizations for autism, and autism groups on Facebook, and all had an official diagnosis on the autism spectrum according to their psychiatrists. Children with an IQ < 85 were excluded, and none of the children had a diagnosis of any additional linguistic or cognitive disorder. In addition, they were monolingual speakers of Dutch and had normal hearing. Teachers and parents confirmed these inclusion and exclusion criteria.

To verify the ASD diagnoses, the Dutch version of the Children's Communication Checklist (CCC-2-NL) (Geurts 2007) was administered to the parents of all the children with ASD. The CCC is a parents' questionnaire investigating the child's social communication and grammatical

difficulties (Bishop 2003). The difference between the sum of scores on the "language areas" (speech, syntax, semantics, and coherence) and the sum of scores on "social communication" (initiation, nonverbal communication, social relations, and interests) reflects the "Social Interaction Difference Index" (SIDI) expressed as a percentile. Children who score above the 90th percentile have more social communication problems than structural language difficulties, whereas the opposite is true for children scoring below the 10th percentile. The results of 26 completed and returned CCC forms show that, as expected, the ASD group has a high SIDI score (M = 82, SD = 20). This indicates that social communication is more of a challenge than structural language in the ASD group, confirming their autism diagnosis.

3.2. *Materials and procedure*

Eleven tests were used, covering different domains—pragmatics, (morpho)syntax, and extralinguistic cognition. The extralinguistic cognition tests were mostly nonverbal so as not to disadvantage any ASD participant with potential structural language impairment and not to confound data on extralinguistic abilities with verbal abilities. Table 2 provides the details of the tests.

3.2.1. *Article Choice Task*[2]

To test article choice, an Elicited Production Task based on Schaeffer (1999) was used. The three contexts in Table 1 (section 2.2) were translated into three conditions. Each condition had six experimental items. The 18 article choice items served as fillers for the Direct Object Scrambling Task described in section 3.1.2 and vice versa. Participants sat next to Experimenter 2 and were asked to describe an event in a picture or in a short video clip on a computer screen to Experimenter 1, who sat opposite the participant and Experimenter 2 and could not see the screen. Before the experiment started, the participants were familiarized with all the characters featuring in the experiment. Sample items for each condition are given in (9):

Table 2. Test battery.

	Cognitive function	Test/Task	References
Pragmatics	Article Choice (AC)	Elicited Production	Schaeffer (1999); Schaeffer & Matthewson (2005)
	Direct Object Scrambling (DOS)	Elicited Production	Schaeffer (1997; 2000)
Morphosyntax	Subject-Verb Agreement (SVA)	Elicited Production	Blom, Orgassa & Polišenská (2008); Duinmeijer (2016)
	Morphosyntax (MS)	Sentence Repetition CELF-4-NL	Semel et al. (2008)
Extralinguistic Cognition	Nonverbal Reasoning (NVR)	Raven's Progressive Matrices	Raven, Raven & Court (2003)
	Nonverbal False Belief (NVFB)	Find-the-eraser	Colle, Baron-Cohen & Hill (2007)
	Nonverbal Inhibition (NVI)	VIMI Hand-Fist Task/Luria's Hand Game	Henry, Messer & Nash (2012)
	Nonverbal Working Memory (NVWM)	Odd-One-Out Task	Henry (2001)
	Verbal Working Memory (VWM)	Digit Span Backward from Wechsler intelligence scale for children—revised	Wechsler (1974)
	Phonological (short-term) Memory (PhM)	Non-Word-Repetition	Rispens & Baker (2012)

[2]The tasks for article choice, direct object scrambling, subject-verb agreement, theory of mind, inhibition, and nonverbal working memory are also described in Schaeffer 2016/2018. The tasks for article choice, nonverbal working memory, verbal working memory, and phonological memory are also described in Schaeffer, Creemers & van Witteloostuijn.

(9) a. Definite condition (target: *de* 'the')
Presentation of picture on screen:

Exp 1: *Hé, wie zie je op het plaatje*? 'Hey, who do you see in the picture?'
Part: Katrijn!
Exp 1: *En wat nog meer*? 'What else do you see?'
Part: *Een bal*! 'A ball!'

Presentation of video-clip of Katrijn rolling ball:

Exp 1: *En wat deed Katrijn daarnet*? 'And what did Katrijn just do?'
Target: *Ze rolde* ***de*** *bal* 'She rolled the ball'
#Ze rolde een bal 'She rolled a ball'

b. Indefinite referential condition (target: *een* 'a')
Presentation of picture on screen:

Exp 1: *Hé, wie zie je op het plaatje*? 'Hey, who do you see in the picture?'
Part: Ernie!
Exp 1: *En wat wat heeft Ernie net gedaan*? 'And what did Ernie just do?'
Target: *Hij heeft* ***een*** *pizza gebakken*. 'He baked a pizza'
#Hij heeft de pizza gebakken. 'He baked the pizza'

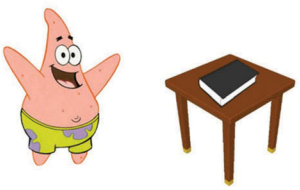
c. Indefinite nonreferential condition (target: *een* 'a')
Presentation of picture on screen:

Exp 1: *Hé, wie zie je op het plaatje*? 'Hey, who do you see in the picture?'
Part: Elmo!
Exp 2: *Elmo zegt: Oh, ik verveel me zo, ik weet niet wat ik moet doen. Oh, weet je wat, ik ga naar de keuken en dan ga ik iets bakken*. 'Elmo says: Oh, I'm so bored, I don't know what to do. Oh, you know what, I'm going to the kitchen and I'm going to bake something.'
Exp 1: *Wat denk je dat Elmo gaat doen in de keuken*? 'Wat do you think Elmo is going to do in the kitchen?'
Target: *Hij gaat **een** taart bakken*. 'He is going to bake a cake'
#Hij gaat de taart bakken. 'He is going to bake the cake.'

3.2.2. *Direct Object Scrambling Task*

To test direct object scrambling, an Elicited Production Task with the same three conditions as for the Article Choice Task was employed: definite referential, indefinite referential, and indefinite nonreferential. Each condition contained six experimental items, and the 18 Article Choice items were used as filler items. The setup was the same as for the Article Choice Task: Experimenter 2 sat opposite the participant, and Experimenter 1 and could not see the picture on the screen. Sample scenarios of the three conditions are provided in (10):

(10) a. Definite referential condition (target: scrambled object)
Presentation of picture on screen:

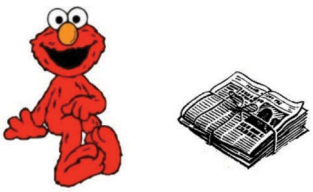


Exp 2: Here is Patrick. Patrick is bored. He says: "Hey, a book! But I don't like books, so *dat ga ik niet lezen*."
that go I not read
'I'm not going to read that.'
Exp 1: I know! *Het boek gaat Patrick wel lezen*.
the book goes Patrick yes read
'Patrick is going to read the book.'

Target: No, *Patrick gaat het boek NIET lezen*. (scrambled)
no, Patrick goes the book NOT read
'No, Patrick is not going to read the book.'
#No, *Patrick gaat NIET het boek lezen*. (nonscrambled)

The preamble (preceding discourse) is crucial in this task. For example, notice that the object in Experimenter 2's last clause (*dat* 'that') is topicalized to a position preceding the finite verb so that we do not give away either a scrambled or a nonscrambled position in the preamble. In Experimenter 1's sentence the relevant direct object is topicalized again. The participant is then expected to correct Experimenter 1 and utter a sentence with a scrambled direct object (starting the response with a subject). If the participant does not begin with a subject, s/he is prompted by Experimenter 2, who says "No, Patrick … ?"

b. Indefinite referential condition (target: scrambled object)
Presentation of picture on screen:



Exp 2: Here is Elmo. "Hey," says Elmo, "three newspapers: 1, 2, 3."
Twee kranten ga ik niet lezen.
two newspapers go I not read
'I am not going to read two newspapers.'
Exp 1: I know! *Twee kranten gaat Elmo WEL lezen!*
Two newspapers goes Elmo yes read
'Elmo is going to read two newspapers.'
Target: No, *Elmo gaat twee kranten NIET lezen*. (scrambled)
no, Elmo goes two newspapers NOT read
'No, Elmo is not going to read two newspapers.'
#No, *Elmo gaat NIET twee kranten lezen* (nonscrambled)

A plural direct object was opted for in this condition because in experimental situations such as these, singular referential indefinites are often changed into a definite, as reported by Schaeffer (1997, 2000).

The third condition, the indefinite nonreferential condition, depicts no objects. It only presents a cartoon figure with a thought bubble. Here the participant is not asked to correct Experimenter 1, but rather Experimenter 1 is not paying attention and asks the participant for help.

c. Indefinite nonreferential condition (target: nonscrambled object)
Presentation of picture:

Exp 2: Here is Dora. "Hey," says Dora, "I feel like going to a garden to pick a flower, but that's not allowed.
"*Dus dat ga ik niet doen*."
so that go I not do
'So I am not going to do that.'
Exp 1: *Oh, ik heb het niet goed gehoord. Wat gaat Dora niet doen*?
oh, I have it not well heard. what goes Dora not do
'Oh I didn't hear it very well. What is Dora not going to do?'
Target: *Dora gaat niet een/geen bloem plukken*. (nonscrambled)
Dora goes not a/no flower pick
'Dora is not going to pick a flower.'
#*Dora gaat een bloem niet plukken*. (scrambled)

3.2.3. *Verbal Inflection Task*

To test verbal inflection, an Elicited Production Task was used in which participants are asked to describe actions presented on cards. This task was developed by Duinmeijer (2016), based on Blom, Orgassa & Polišenská (2008), and contained 60 experimental items.[3] Each of the five conditions (first-, second-, and third-person singular and first- and second-person plural) contained 12 items, using six transitive verbs twice (*film, drink, bake, read, clean*, and *comb*). The participant, the experimenter, and a doll named Kim each received their own pile of 30 upside-down cards representing actions related to the six verbs previously mentioned. Each round the top card of each pile was turned over. Subsequently, the participant had to answer questions by the experimenter, such as "What are you doing?," "What am I doing?," "What is Kim doing?," "What are we doing?" Plurals were elicited by having the same action on two or three of the cards. An example is given in (11):

(11) Example elicitation of verbal inflection

Ik aai een hond
I pet a dog
'I am petting a dog.'

Jij bakt een ei
you fry an egg
'You are frying an egg.'

Kim leest de krant
Kim reads a newspaper
'Kim is reading a newspaper.'

3.2.4. *Sentence Repetition Task*

Scores of sentence repetition were obtained from the Sentence Recall subtest of the Dutch version of the Clinical Evaluation of Language Fundamentals (CELF-4-NL) (Semel et al. 2008). In this Sentence Recall test, the experimenter reads sentences of various syntactic structures one by one, as illustrated in (12):

(12) a. *Weet iemand wie de nieuwe leraar is*?
knows someone who the new teacher is
'Does anyone know who the new teacher is?'

[3] I thank Iris Duinmeijer (2016) for kindly sharing her experimental materials with me.

b. *De jongens hebben de appels niet opgegegeten.*
the boys have the apples not up-eaten
'The boys didn't eat the apples.'

c. *De auto werd door de bus voorbijgereden.*
the car became by the bus passed
'The car was passed by the bus.'

d. *De grote, bruine hond heeft al het eten van de poes opgegeten.*
The big brown dog has all the food of the cat up-eaten
'The big brown dog ate all the cat's food.'

The participant is instructed to repeat these sentences verbatim. The experimenter never repeats a sentence. The following scores can be earned:

- 3 points: Sentence is repeated verbatim, without any changes.
- 2 points: There is one error/change in the repetition as compared to the original sentence.
- 1 point: There are two or three errors/changes.
- 0 points: There are four or more errors/changes.

3.2.5. *Raven's Progressive Matrices (nonverbal reasoning)*

To test the participants' nonverbal reasoning ability, Raven's Progressive Matrices (Raven, Raven & Court 2003) were administered. This is a standardized test on nonverbal IQ for children and adults of any age.

This test consists of 60 multiple choice items, listed in order of difficulty. Each test item consists of a visual black-and-white geometric pattern with a missing piece. The participant is asked to pick the missing element from six to eight choices to complete the pattern.

3.2.6. *Find-the-eraser task (nonverbal false belief)*

To test nonverbal false belief, a slightly adapted version of the Colle, Baron-Cohen & Hill (2007) task was used. In the three false belief items, there are two boxes with a lid and a small object (e.g., an eraser). A screen is put between the participant and Experimenter 1. Experimenter 2 can see in which box Experimenter 1 puts the eraser, whereas the participant cannot. Experimenter 2 then leaves, and the screen is removed. Then, in view of the participant, Experimenter 1 changes the position of the boxes. Experimenter 2 returns and has to point at the box that (she thinks) contains the eraser. Based on Experimenter 2's pointing, the participant has to decide which box contains the eraser (namely, the other box, that Experimenter 2 did not point at). The correct answer can only be derived from reasoning through Experimenter 2's perspective.

3.2.7. *Hand-fist game (nonverbal inhibition)*

The participants' nonverbal (motor) inhibition was tested through Henry, Messer & Nash's (2012) VIMI Hand-Fist Task or "Luria's hand game." The task contains two conditions of 20 trials each. The first condition requires the participant to copy the experimenter's handshape (either a finger or a fist). In the second condition the participant is asked to inhibit the copy response and show the alternative handshape. These two conditions are repeated with two other handshapes—flat vertical versus flat horizontal. The current study considers the inhibition responses only.

3.2.8. *Odd-One-Out Task (nonverbal working memory)*

Nonverbal working memory was tested through Henry's (2001) "Odd-One-Out" Task. In this task the participant is asked to point at the odd-one-out figure in a row of three geometrical figures on a computer screen. Subsequently, a new screen with three blank cells is shown, and the participant

has to indicate the (blank) positions where the odd-one-out figures were before (maximum of six rows of cells). An illustration is given in (13):

(13) Example Odd-One-Out Task
First screen:

Second screen:

3.2.9. *Digit Span Backward task (verbal working memory)*

Digit Span Backward is a subtest of the Wechsler Intelligence Scale for Children and tests verbal working memory (WISC-III-NL; Kort et al. 2005). The participant is asked to repeat orally presented digit sequences of increasing length (three to eight digits) in reverse order. Each sequence contains two trials. The test is cut off when the participant gives an incorrect response to both trials.

3.2.10. *Non-Word Repetition Task (phonological memory)*

Phonological (or short-term) memory was tested through Rispens & Baker's (2012) Non-Word Repetition Task. Participants are asked to repeat 40 non-words that vary in length (two to five syllables) and phonotactic probability. The items range from non-words with two syllables with high phonotactic probability, e.g., *kuimop*, to items with five syllables with low phonotactic probability, e.g., *geumuwoekuubir*.

3.3. *Statistical analysis*

To determine potential significant predictors, two multilevel analyses were performed in SPSS. In model 1, the dependent variable was the combined score on the referential conditions of the direct object scrambling test; the nesting variable was Group (ASD or TD), the factor variable was Group (ASD or TD), and the independent variables were the scores on: Age, Odd-One-Out, Raven's, Fist-Finger Game, Theory of Mind, Non-Word Repetition, Digit Span Backward, Sentence Repetition, Subject-Verb Agreement, and CCC. In model 2, the dependent variable was the score on the definite condition of the article choice test; the nesting variable was Group (ASD or TD), the factor variable was Group (ASD or TD), and the independent variables were the scores on: Age, Odd-One-Out, Raven's, Fist-Finger Game, Theory of Mind, Non-Word Repetition, Digit Span Backward, Sentence Repetition, Subject-Verb Agreement, and CCC.

In addition, four normal regression analyses were conducted. Given the fact that we had a relatively large number of potential predictors and a relatively small number of participants,[4] we

[4]We thank an anonymous reviewer for pointing this out.

increased the power of the analyses by using "forward selection." Forward selection is a stepwise variable selection procedure in which independent variables are entered into the model one by one (rather than simultaneously), based on the strength of their correlation with the dependent variable, with the strongest one going first (Field 2009).

The following four models with the dependent and independent variables are listed. Models 1 and 2 provide the regression analyses for the HFA group, models 3 and 4 for the TD group.

Model 1: Dependent variable: combined score on the referential conditions of the direct object scrambling test. Independent variables: Age, Odd-One-Out, Raven's, Fist-Finger Game, Theory of Mind, Non-Word Repetition, Digit Span Forward, Digit Span Backward, Sentence Repetition, Subject-Verb Agreement, and CCC.
Model 2: Dependent variable: score on the definite condition of the article choice test. Independent variables: Age, Odd-One-Out, Raven's, Fist-Finger Game, Theory of Mind, Non-Word Repetition, Digit Span Forward, Digit Span Backward, Sentence Repetition, Subject-Verb Agreement, and CCC.
Model 3: The same as model 1 but without CCC score because the CCC was not administered to the TD group.
Model 4: The same as model 2 but without CCC score because the CCC was not administered to the TD group.

4. Results

First of all, Table 3 presents the descriptive statistics for all tasks for the ASD group and the TD group and an indication (with *) of the significant differences between the groups (as also reported in Schaeffer 2016/2018, Schaeffer 2017, and Schaeffer, Creemers & van Witteloostuijn 2018).

As reported in Schaeffer (2016/2018) and Schaeffer, Creemers & van Witteloostuijn (2018), the ASD group produces correct definite articles in the definite condition of the article choice test significantly less often than the TD group. No significant differences were found in the indefinite conditions of the article choice test. Schaeffer (2016/2018) and Schaeffer (2017) report that the ASD group fails to scramble direct objects significantly more often in the referential conditions of the direct object scrambling test than the TD group. No significant differences were found in the indefinite nonreferential condition of the direct object scrambling test. The third test for which a significant difference was found between the ASD and the TD group (see also Schaeffer, Creemers & van Witteloostuijn 2018) is phonological memory (as tested by a NWR Task). None of the other tests revealed significant differences between the ASD and TD groups.

Table 3. Descriptive statistics for all tasks and both groups and significance (*) of group comparisons.

	N		Min		Max		Mean		SD		
Test	ASD	TD	ASD	TD	ASD	TD	ASD	TD	ASD	TD	Significance
AC-def	27	27	2	3	6	6	5	5.7037	1.30089	0.72403	*
DOS-ref	27	27	0	3	12	12	7.1481	9.7037	3.87004	2.97185	*
SVA	26	27	.22	0.08	1	1	0.9469	0.9570	0.15753	0.17681	
MS	25	27	30	34	88	90	61.4	69.037	18.94070	13.42925	
NVR	27	26	23	5	97	97	62.7407	72.5	20.94791	25.10339	
NVFB	27	27	1	0	3	3	2.2963	1.8519	0.6688	0.7181	
NVI	26	23	8	16	40	39	25.6154	29.4783	9.54181	6.34515	
NVWM	26	26	1	2	6	6	4.2692	4.9231	1.53773	1.26248	
VWM	26	27	2	3	9	11	4.5	5.9630	1.772	2.20979	
PhM	26	27	0.45	0.43	0.8	0.88	0.6298	0.7056	0.11619	0.10127	*
Valid N (listwise)	24										

Note. AC-def = Article Choice = definite condition; DOS-ref = Direct Object Scrambling = referential conditions (definite and referential indefinite); SVA = Subject-Verb Agreement; MS = Morphosyntax; NVR = Nonverbal Reasoning; NVFB = Nonverbal False Belief; NVI = Nonverbal Inhibition; NVWM = Nonverbal Working Memory; VWM = Verbal Working Memory; PhM = Phonological Memory.

Secondly, we calculated if there was a correlation between the scores on the two pragmatic tests Article Choice (definite condition) and Direct Object Scrambling (referential conditions) and on False Belief across the two groups. Since the data of both variables were not normally distributed, a (nonparametric) Spearman's Rho test was performed. After a Bonferroni correction on the p value ($p < .016$), this test revealed no significant correlations between (i) Article Choice and Direct Object Scrambling, r_{sp} (54) = .169, p = .222; (ii) Article Choice and False Belief, r_{sp} (54) = −.180, p = .193; and (iii) Direct Object Scrambling and False Belief. r_{sp} (54) = −.273, p = .046.[5]

Thirdly, two multilevel analyses were performed across the two groups to determine which independent variables could predict article choice performance and which independent variables could predict direct object scrambling. However, since the ASD and the TD group differed from each other insufficiently, these analyses could not be computed. As the starting point of the study was the differences between the ASD and TD groups on article choice and direct object scrambling performance, we reverted to two separate regression analyses for each group (ASD vs. TD) with forward selection.

The forward selection regression analysis rendered no significant predictors for Article Choice or Direct Object Scrambling in the TD group: The analysis found no variable that was strong enough to predict Article Choice performance.

Regarding the ASD group, the forward selection regression analysis revealed one significant predictor for Direct Object Scrambling—NWR (phonological memory). The model with NWR as a predictor explains 40% of the variance in the ASD Direct Object Scrambling scores (R^2 = .400; B-coefficient = 21,484, p = .001). Finally, no variable was strong enough to predict Article Choice performance in the ASD group.[6]

5. Discussion

The main goal of this study is to answer the question as to what causes the problems with article choice and direct object scrambling in Dutch-speaking children aged 6–14 with ASD, as reported in Schaeffer (2016/2018). As the descriptive and inferential statistics show, the children with ASD perform significantly lower than the TD children on (the definite condition of the) Article Choice test and (the referential conditions of the) Direct Object Scrambling test.

The results of the forward selection regression analyses show that no significant predictors of article choice and direct object scrambling performance were found in the TD group, nor was there a correlation between article choice, direct object scrambling, and false belief performance. This may be due to the fact that the TD children performed at ceiling on article choice and object scrambling. This is not surprising, as all the children in this study were older than 6, and previous studies show that TD children acquire article choice and direct object scrambling between the ages of 3 and 4 (article choice: Schaeffer & Matthewson 2005; direct object scrambling: Schaeffer 1997, 2000). Moreover, the TD children's scores on the other tests were mostly at ceiling as well.

Turning to the hypotheses for the children with ASD as formulated in section 2.6, it was first hypothesized that article choice, direct object scrambling, and false belief abilities are each influenced by perspective taking abilities (Hypothesis 1). Therefore, article choice, direct object scrambling, and false belief abilities were predicted to correlate. However, no significant correlations were found between the scores on the relevant conditions of either article choice or direct scrambling and false belief scores. As such, Hypothesis 1 is not supported.

Nonetheless, a caveat regarding methodology is in place here. The nonverbal Theory of Mind Task adapted from Colle, Baron-Cohen & Hill (2007) contained only three false belief items, which the scores of the ASD and TD groups were based on. Furthermore, as reported by Schaeffer, Creemers & van Witteloostuijn (2018), and shown in the descriptive statistics, the TD children,

[5]For the complete SPSS tables, see Appendix A.
[6]For the complete SPSS tables, see Appendix B.

who were all older than 6, scored only 62% correct on the false belief items of this test. This is surprising in light of the fact that TD children are supposed to acquire false belief around the age of 4 (Wimmer & Perner 1983). Moreover, the children with ASD did not perform significantly more poorly than the TD children on this test. In fact, they reached slightly (but not significantly) higher accuracy scores: 77%. The low number of relevant experimental items, the low TD scores, and the relatively high ASD scores suggest that the nonverbal false belief test employed here may not be the most adequate one. It is important that in future studies more adequate tests of false belief will be developed (see Durrleman in this special issue). The fact that no correlation was found between direct object scrambling and article choice scores suggests a difference between the two phenomena: Although pragmatic knowledge of speaker/hearer assumptions (or perspective taking) is needed for both, syntactic knowledge of possible direct object positions is required for direct object scrambling only.

The second hypothesis was that article choice and direct object scrambling are influenced by phonological and working memory (Hypothesis 2). The forward selection regression analyses revealed one significant predictor of direct object scrambling performance—phonological memory (tested by the NWR). Neither verbal working memory (tested by Digit Span Backward) nor nonverbal working memory (tested by Odd-One-Out) predicts direct object scrambling performance. Furthermore, no significant predictors were found for article choice performance. Thus, only part of Hypothesis 2 is supported: While phonological memory does predict direct object scrambling performance, neither verbal nor nonverbal working memory predicts it. Moreover, neither phonological memory nor verbal or nonverbal working memory predicts article choice performance. Prima facie, this seems contradictory to Schaeffer, Creemers & van Witteloostuijn's results, who report a correlation between phonological memory and the definite condition of article choice for their ASD and SLI groups combined. However, no correlation was found for any of the groups separately, and Schaeffer, Creemers & van Witteloostuijn argue that the significance of the correlation between phonological memory and the definite condition of article choice for the combined groups is mainly due to the participants with SLI. As such, the results of the current study corroborate Schaeffer, Creemers & van Witteloostuijn's results on ASD. The influence of phonological memory on direct object scrambling can be explained by the hypothesis that the referential conditions of direct object scrambling require consideration of the preceding discourse and thus holding the preceding discourse in memory.

Thirdly, we hypothesized that direct object scrambling is influenced by syntactic abilities but that article choice is not. The first part of this hypothesis receives no evidence, as the scores of no morphosyntactic measure (either subject-verb agreement or sentence repetition) predicts performance on the referential conditions of direct object scrambling. The second part of Hypothesis 3 is trivially supported (as the results do not differ from the results relevant to the first part): The scores of no morphosyntactic measure (neither subject-verb agreement nor sentence repetition) predicts performance on the definite condition of article choice. Thus, although direct object scrambling is argued to have an additional syntactic component (see also Schaeffer 2017)—as opposed to article choice—it does not seem to be influenced by the morphosyntactic abilities we measured by subject-verb agreement and sentence repetition tests. This may be explained by the fact that it is pragmatics (referentiality, established by knowledge of speaker/hearer assumptions) that drives the (syntactic) word order in direct object scrambling. If pragmatics fails, correct word order fails. In other words, syntactic knowledge may be there but is of no use if pragmatics fails in direct object scrambling.

As for our open research questions, the first one (Are article choice and/or direct object scrambling influenced by inhibition?) cannot be answered with "yes." We find no evidence that the scores on Luria's hand game predict those on article choice and/or direct object scrambling.

The second open research question asked whether article choice and/or direct object scrambling are influenced by nonverbal reasoning. This cannot be confirmed either—Raven's Progressive Matrices scores do not predict performance on either article choice or direct object scrambling.

Finally, open question number 3 asked whether age is a predictive factor for language performance in children with ASD. The results indicate no evidence for this. This means that even some of

the oldest children in the ASD group still perform poorly on the definite condition of direct object scrambling and the referential conditions of article choice. Nevertheless, we need to realize that the current study employs a cross-sectional rather than a longitudinal methodological design. Ideally, future studies should follow a group of children with ASD from age 6 to age 14 to investigate whether they truly improve with age or not.

Interestingly, CCC SIDI scores were not significantly correlated with article choice or direct object scrambling scores either. This may seem surprising, given the fact that the SIDI score provides an indication of the participant's communicative abilities, abilities that are often related to linguistic pragmatics. However, it is important to note that (i) as opposed to all the other tasks of the current study, the CCC is a questionnaire for parents, who need to estimate the child's communicative abilities; and (ii) the type of questions posed in the CCC—see (14) for some examples—seem not all directly related to knowledge of speaker/hearer assumptions and/or preceding discourse, as article choice and direct object scrambling do.

(14) Sample questions CCC—Parents are asked to give a score of 0–3 to the following statements about their child (0: less than once a week; 3: more than twice a day).

a. *Praat herhaaldelijk over dingen waarin niemand geïnteresseerd is.*
'Talks repetitively about things in which nobody is interested.'
b. *Kijkt de persoon niet aan tegen wie hij/zij praat.*
'Doesn't look the person whom s/he talks to in the eyes.'
c. *Mist de essentie van woordspelingen.*
'Misses the essence of word plays.'
d. *Praat over dingen die hij/zij uit het hoofd heeft geleerd, bijvoorbeeld, de hoofdsteden van de wereld, of de namen van verschillende soorten dinosauriërs.*
'Talks about things s/he learned by heart, for example, the world's capitals, or the names of different types of dinosaurs.'
e. *Vertelt mensen dingen die zij al weten.*
'Tells people things they already know.'
f. *Reageert positief als een nieuwe en onbekende activiteit wordt voorgesteld.*
'Reacts positively when a new and unknown activity is being proposed.'
g. *Waardeert ironie. Zou geamuseerd zijn in plaats van in de war als iemand zou zeggen "wat is het toch een heerlijke dag" terwijl het hard regent.*
'Appreciates irony. Would be amused instead of confused when someone would say "it's a beautiful day" while it's raining.'
h. *Laat zien dat hij/zij bezorgd is als andere mensen overstuur zijn.*
'Shows that s/he is concerned when other people are sad.'
i. *Je kunt een leuke, interessante conversatie met hem/haar hebben.*
'You can have a fun, interesting conversation with her/him.'
j. *Lacht op gepaste momenten wanneer hij/zij met anderen praat.*
'Laughs at the right moments when s/he talks to other people.'

Returning now to our initial picture in Figure 1 in the introduction: What do the results mean with regard to the connections between the linguistic and extralinguistic cognitive functions that were measured in the current study? The results suggest a link only between phonological memory and direct object scrambling (DOS). This link and its predictive direction are represented by the arrow in Figure 2.

This link was predicted and can be explained by the hypothesis that the referential conditions of direct object scrambling require consideration of the preceding discourse and thus holding the preceding discourse in memory. However, the fact that we did not find this for the definite condition of article choice (for which the preceding discourse must also be held in memory), weakens the

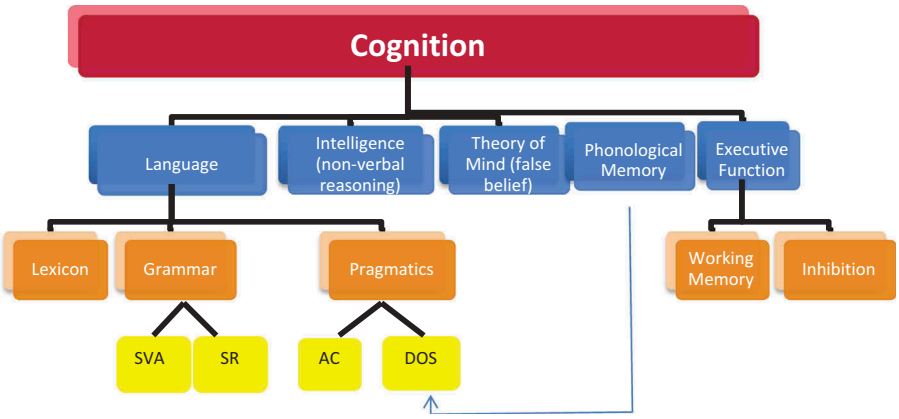


Figure 2. Predictive link between linguistic and extralinguistic cognitive functions. SVA = subject-verb agreement; SR = sentence repetition; AC = article choice; DOS = direct object scrambling.

theoretical basis for the link between phonological memory and (the referential conditions of) direct object scrambling considerably. Moreover, the lack of predictive power of working memory (supposedly used to manipulate the preceding discourse) also casts doubt on the role that memory plays in the referential conditions of direct object scrambling or the definite condition of article choice.

In summary, except for the link between phonological memory and direct object scrambling, our results show no evidence for lines to be drawn between any of the language functions on the one hand and extralinguistic cognitive functions on the other hand. Whether there is a connection between false belief abilities and article choice and/or direct object scrambling, we leave open for future research, as we argued that the false belief test we employed may not be adequate. This raises the question as to whether there are perhaps other cognitive abilities that are necessary for the linguistic-pragmatic phenomena of article choice and direct object scrambling but that were not tested in the current study. Although article choice and direct object scrambling differ in that direct object scrambling has an obvious syntactic component (word order) while article choice does not, they also have properties in common. Besides the hypothesized perspective taking, requiring knowledge of speaker/hearer assumptions, the definite condition of the article choice test and the referential conditions of the direct object scrambling test make use of a connection with the preceding discourse. In fact, Ariel (1988) argues that article choice is discourse-based. In the following paragraphs we speculate on a different cognitive skill that may be required for the choice of a definite article and the scrambling of a definite direct object—central coherence.

Frith (1989) defines central coherence as a central system that integrates sources of information to establish meaning. Frith (1989) hypothesizes that individuals with ASD have a tendency to process locally (rather than globally), which may affect coherence. Applying central coherence to language, Jolliffe & Baron-Cohen (1999) state that " … coherence is the ability to make contextually meaningful connections between linguistic information in short-term or working memory" (Jolliffe & Baron-Cohen 1999:149). They further argue that individuals with ASD "have a preference not to strive for coherence unless instructed to do so, or unless they make a conscious decision to do so" (Jolliffe & Baron-Cohen 1999:149).

Making contextually meaningful connections between linguistic information, i.e., coherence, is exactly what seems to be needed in the definite condition of article choice and the referential conditions of direct object scrambling. Let us first consider article choice. (15) repeats the sample item of the definite condition of the article choice test as presented in section 3.1.1. To produce the correct target article *de* 'the,' the participant needs to make a (global) connection between this target

article and the preceding discourse: *De* 'the' must be used because the referent of BALL has been introduced in the preceding discourse with the indefinite article *een* 'a.'

(15) a. Definite condition (target: *de* 'the')
Presentation of picture on screen:

Exp 1: *Hé, wie zie je op het plaatje*? 'Hey, who do you see in the picture?'
Part: Katrijn!
Exp 1: *En wat nog meer*? 'What else do you see?'
Part: *Een bal*! 'A ball!'

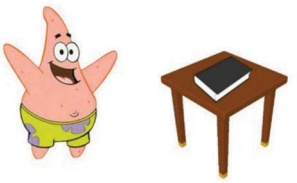
Presentation of video-clip of Katrijn rolling ball:

Exp 1: *En wat deed Katrijn daarnet*? 'And what did Katrijn just do?'
Target: *Ze rolde **de** bal* 'She rolled the ball'
#Ze rolde een bal ("She rolled a ball")

Note that a connection between the preceding discourse and an *in*definite article is not required: An indefinite article introduces a new referent and can be used without any preceding discourse.

For direct object scrambling a similar reasoning holds, as illustrated in (16), repeated from section 3.1.2:

(16) a. Definite referential condition (target: scrambled object)
Presentation of picture on screen:



Exp 2: Here is Patrick. Patrick is bored. He says: "Hey, a book! But I don't like books, so *dat ga ik niet lezen*."
that go I not read
'I'm not going to read that'

Exp 1: I know! *Het boek gaat Patrick wel lezen*
the book goes Patrick yes read
'Patrick is going to read the book.'

Target: No, *Patrick gaat het boek NIET lezen*
no, Patrick goes the book NOT read
'No, Patrick is not going to read the book.'
#No, *Patrick gaat NIET het boek lezen*

The direct object *het boek* 'the book' in the target response is highly referential because of the fact that it was mentioned several times in the preceding discourse. This causes scrambling to a higher position in the sentence. Thus, to scramble correctly, one must connect the target sentence to information from the preceding discourse. In contrast, an indefinite object does not have an antecedent and therefore does not require a connection to the preceding discourse.

Previous studies show that individuals with ASD prefer to make connections locally, rather than globally. For example, Jolliffe & Baron-Cohen (2001) administered a visual object integration test to 17 high-functioning adults with ASD, 17 adults with Asperger's Syndrome, and 17 neurotypical adults. Their object integration test is partly similar to Hooper's (1983) Visual Organization Test (VOT) that tests the ability to conceptually rearrange disarranged pictures such as the ones in Figure 3.

Besides having to conceptually integrate the components to make the most coherent scene, the participants in Jolliffe and Baron-Cohen's (2001) task also had to compare for similarities. The results show that the high-functioning adults with ASD and with Asperger's Syndrome were significantly impaired in their ability to integrate objects (global processing) but that they were not impaired in looking for similarities (local processing). Reduced global visual processing in adults with ASD has further been demonstrated by a more recent study by Booth & Happé (2018), who controlled for the direct trade-off between global and local processing, which makes it difficult to determine whether results reflect reduced global processing, increased local processing, or both. Booth & Happé (2018) report that their adult participants with ASD identified fragmented figures more slowly than IQ-matched controls. A similar result was found regarding sensitivity to global geometric impossibility. These results indicate that reduced visual global integration is one important aspect of weak central coherence in ASD.

Global versus local visual processing has been investigated in children too. Gross (2006) tested 24 children with ASD, mean age 8;05, on Navon's (1977) global-local visual processing task. In such a task, the experimental stimuli consist of a shape made up of smaller objects, for example, a heart shape made of jacks. The response options consist of pictures (i) preserving the

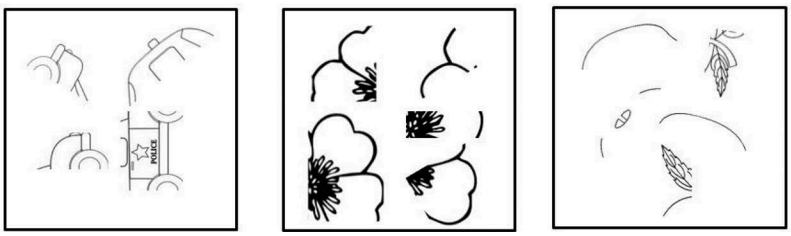


Figure 3. Sample pictures of disarranged objects in Hooper Test.

configuration of the target, i.e., a heart (global response); (ii) showing items similar to the parts of the target, i.e., jacks (local response); (iii) showing an item dissimilar to the target, i.e., a circle (unrelated response). After the participant is shown the picture of the experimental stimulus, the picture is turned over, and she is asked: "Which one is like the one I just showed you?" Gross's (2006) results show that the children with ASD gave significantly fewer global responses than the control group. The number of local responses did not differ significantly between the groups. These findings provide further evidence for the hypothesis that individuals (including children) with ASD have problems with global processing.

Evidence for weak linguistic global processing comes from a study by Booth & Happé (2010), who report that 176 individuals (aged 8–25) with ASD provide more local than global responses on a sentence completion task with sentences such as "In the sea there are fish and … " in which the local response is "chips" and the global response something like "corals" or "dolphins." The results further show that this weak central coherence in individuals with ASD is not related to inhibitory control.

Another way to investigate linguistic central coherence or global processing would be the administration of a coloring task testing so-called bridging (Bosch, Zuckerman & Pinto 2017; 2020). *Bridging* is the phenomenon of using a definite article with a noun whose referent is part of a referent introduced (with an indefinite article) in the preceding discourse, such as FLAG and BOAT respectively in the example in (17):

(17) *Kijk, er vaart* ***een boot*** *voorbij.* ***De vlag*** *is rood.*
'Look, a boat is passing by. The flag is red.'

In the coloring task by Bosch, Zuckerman & Pinto (2017), who conducted this experiment with TD Dutch-acquiring children, the participant is instructed to color the correct flag red in the picture in Figure 4.

To do so correctly, the participant needs to make a global connection between the definite noun phrase in the second sentence and the indefinite noun phrase in the first sentence and color the flag on the boat red. Local processing of the definite noun phrase "the flag" (without "building a bridge" to the noun phrase in the first sentence) could result in coloring the castle's flag red. Assuming that global processing/central coherence abilities are required for bridging, it is predicted that high-functioning children with ASD between the ages of 6 and 14 perform more poorly on this task than TD age controls.

In summary, impairment in global processing may lead to errors in discourse-related linguistic phenomena such as the choice for a definite article and scrambling of definite direct objects. Therefore, future studies on such discourse-related linguistic phenomena in ASD populations should include verbal and nonverbal global versus local processing tasks.

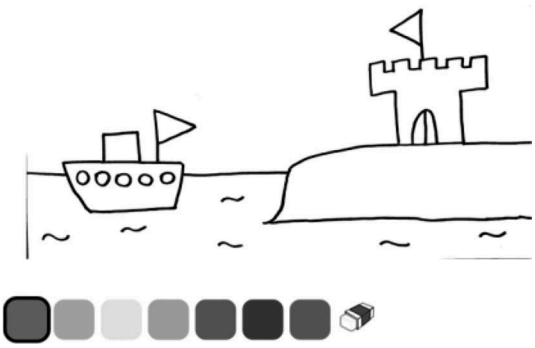


Figure 4. Sample picture of coloring task testing bridging.

6. Conclusion

This study addressed the question as to why the Dutch-speaking children with ASD in the study by Schaeffer (2016/2018) perform below the TD norm on the pragmatics-driven linguistic phenomena of article choice and direct object scrambling. Despite the large test battery, including several extralinguistic cognitive tests and (morpho)syntactic tests, the only significant predictor found was phonological memory, explaining 40% of the scores on the referential conditions of the Direct Object Scrambling test (but not of the definite condition of the Article Choice test). The results show no evidence of influence of morpho-syntactic skills, (nonverbal) intelligence, (nonverbal) false belief, or executive functions (including working memory) on article choice or direct object scrambling performance. In this respect, it is interesting to compare the results of the current study with those of Eigsti's contribution to this special issue, who does find correlations between working memory and linguistic skills.

As for the results on false belief, it was noted that the nonverbal task employed to test this (adapted from Colle, Baron-Cohen & Hill 2007) may not have been adequate and that there is a need to develop other nonverbal Theory of Mind/False Belief tests. The contribution by Durrleman in the current special issue may provide some solutions to this problem.

Another cognitive skill that may contribute to article choice and/or direct object scrambling, but that was not tested in the current study, is central coherence. It was suggested to include verbal and nonverbal central coherence tests in future studies testing linguistic-pragmatic skills in children with HFA.

Finally, it is important to note that the current study is limited to only a subgroup of children with ASD: children who are high-functioning (IQ > 85), without any known structural language impairments. To obtain better insights in the connections between language and extralinguistic cognitive abilities, children on the entire autism spectrum need to be investigated, including low-functioning children with ASD and children with structural language impairments (ALI).

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Appendix A

Spearman's Rho correlation on Article Choice, Direct Object Scrambling, and False Belief scores for both groups (ASD and TD) together

Nonparametric Correlations

Correlations

			Art.choice	ScramblingDefIndef	ToM
Spearman's rho	Art.choice	Correlation Coefficient	1,000	,169	-,180
		Sig. (2-tailed)	.	,222	,193
		N	54	54	54
	ScramblingDefIndef	Correlation Coefficient	,169	1,000	-,273*
		Sig. (2-tailed)	,222	.	,046
		N	54	54	54
	ToM	Correlation Coefficient	-,180	-,273*	1,000
		Sig. (2-tailed)	,193	,046	.
		N	54	54	54

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix B

Forward selection regression analysis ASD group Direct Object Scrambling

Variables Entered/Removed[a,b]

Model	Variables Entered	Variables Removed	Method
1	NWR	.	Forward (Criterion: Probability-of-F-to-enter <= ,050)

a. Group = HFA

b. Dependent Variable: ScramblingDefIndef

Model Summary[a,c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	,632[b]	,400	,372	3,13446	,400	14,638	1	22	,001	2,020

a. Group = HFA

b. Predictors: (Constant), NWR

c. Dependent Variable: ScramblingDefIndef

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	143,812	1	143,812	14,638	,001[c]
	Residual	216,147	22	9,825		
	Total	359,958	23			

a. Group = HFA

b. Dependent Variable: ScramblingDefIndef

c. Predictors: (Constant), NWR

Coefficients[a,b]

Model		Unstandardized Coefficients: B	Unstandardized Coefficients: Std. Error	Standardized Coefficients: Beta	t	Sig.	Correlations: Zero-order	Correlations: Partial	Correlations: Part	Collinearity Statistics: Tolerance	Collinearity Statistics: VIF
1	(Constant)	-6,354	3,602		-1,764	,092					
	NWR	21,484	5,616	,632	3,826	,001	,632	,632	,632	1,000	1,000

a. Group = HFA

b. Dependent Variable: ScramblingDefIndef

Excluded Variables[a,b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics: Tolerance	Collinearity Statistics: VIF	Collinearity Statistics: Minimum Tolerance
1	Age	,070[c]	,385	,704	,084	,864	1,157	,864
	OOO.level	-,285[c]	-1,441	,164	-,300	,664	1,505	,664
	Raven	,012[c]	,069	,946	,015	,971	1,030	,971
	Inhibition	,143[c]	,815	,424	,175	,896	1,116	,896
	ToM	-,250[c]	-1,523	,143	-,315	,955	1,048	,955
	B.digitspan	,181[c]	1,046	,307	,223	,904	1,106	,904
	sentence.repetition	,163[c]	,572	,574	,124	,347	2,885	,347
	subj.verb.agr	,188[c]	1,097	,285	,233	,917	1,091	,917
	CCC	-,098[c]	-,506	,618	-,110	,761	1,315	,761

a. Group = HFA

b. Dependent Variable: ScramblingDefIndef

c. Predictors in the Model: (Constant), NWR